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Japan
03-104222

PLASMA PROCESSING EQUIPMENT
[Purazuma Shori Sochi]

Hisamichi Ishioka

UNITED STATES PATENT AND TRADEMARK OFFICE
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SPECIFICATION /1[1]

I. Title of the Invention

Plasma Processing Equipment

II. Claims

1. A plasma processing equipment in which a plasma is generated in a vacuum vessel and the surface of a sample arranged in said vacuum vessel is treated by use of this plasma is characterized by providing with a shield which is arranged between the sample and the inner wall of said vacuum vessel and shields the inner wall of said vacuum vessel from the plasma and a coolant introducing pipe for introducing a coolant for cooling said shield into the vacuum vessel.

III. Detailed Description of the Invention

[Field of Industrial Application]

This invention relates to a plasma processing equipment in which a plasma is generated in a vacuum vessel and the surface of a sample arranged in said vacuum vessel is treated by use of this plasma and relates to the constitution of said plasma processing equipment for quickly carrying out a plasma cleaning for removing reaction products depositing on and adhering to the inner wall of said vacuum vessel in the plasma processing.

[Prior Art]

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[1]Numbers in the margin indicate pagination in the foreign text.

In a plasma processing equipment for treating the surface of a sample such as a wafer, etc. by use of a plasma like a plasma CVD equipment, as represented by Japan Kokai 61-133386, a shield for shielding the inner wall of a vacuum vessel from the plasma must be arranged to prevent contaminations of heavy metals due to Cr, Ni, etc. generating from stainless steel for constructing the vacuum vessel. However, reaction products deposit on the inner surface of this shield in the plasma processing and soon peel off. They adhere to the sample surface and become a reason for inferior goods, adhere to O-rings for keeping the vacuum to cause vacuum leak and lower the operation rate.

A plasma cleaning process represented by Japan Kokai 60-59739 is given as a prior art for improving these drawbacks. A plasma cleaning gas composed of an etching gas, etc. is made into a plasma and the plasma acts on the wall of object to be cleaned to remove the adhering matter of said wall, but the process had such a disadvantage of long cleaning time. As a countermeasure with it, the applicants same as in the present invention formerly proposed a process (in the course of application, and the application number is unknown) in which a cusp magnetic field is generated in a vacuum vessel, this magnetic field is allowed to act on a plasma to collect the plasma on the circumference of /2 ~~wall of object to be cleaned, and the cusp magnetic field is~~ moved in the up-and-down direction of a shield to clean it

efficiently.

[Subject to Be Solved by the Invention]

When the plasma cleaning is carried out by a cusp magnetic field, the plasma is concentrated on a part of inner wall of a shield to heat it. According to Japan Kokai 63-254731, the heating of shield shortens the plasma cleaning time, on the other hand, it is feared that the base material of shield itself evaporates if heated too much. Therefore, the plasma density is restricted and there is a limitation in shortening the cleaning time.

Moreover, even if the cusp magnetic field is not used, the energy added into the plasma is increased so as to shorten the cleaning time, the shield is abnormally heated and there is a limitation in shortening the cleaning time likewise.

The purpose of this invention is to provide the constitution of a plasma processing equipment which enables a cleaning of objective wall without a restricting the plasma density and thereby sharply shortens the cleaning time than before.

[Means for Solving the Subject]

To solve the above subject, in this invention, a plasma processing equipment in which a plasma is generated in a vacuum vessel and the surface of a sample arranged in said vacuum vessel is treated by use of this plasma is characterized by providing with a shield which is arranged between the sample and the inner

wall of said vacuum vessel and shields the inner wall of said vacuum vessel from the plasma and a coolant introducing pipe for introducing a coolant for cooling said shield into the vacuum vessel.

[Functions]

Thus, abnormal heating of the inner surface of shield is prevented and the regulation of flow rate of a coolant introduced from the external of said vacuum vessel according to the plasma density which becomes a reason for the abnormal heating is also made possible by taking an equipment constitution wherein a sample and the inner wall of a vacuum vessel are isolated with a shield and the shield is cooled with the coolant, therefore this invention enables a plasma cleaning using a cusp magnetic field without evaporation of base material of said shield until the possible maximum plasma density and sharply shortens the cleaning time than before during the cleaning.

[Actual Examples]

First, a microwave plasma CVD equipment of Fig. 5 is illustrated as one example of the plasma processing equipment taken as target by the present invention. A space enclosed by a plasma-generating chamber, a reaction chamber 2 and a microwave transmitting window 5 is vacuum exhausted by a non-illustrated exhaust system via an exhaust outlet 16. A microwave 10 introduced from the atmosphere side via a waveguide tube 15

transmits the microwave transmitting window 5 to generate a plasma 20 by ionizing a plasma-generating gas 12 (e.g., nitrogen: N_2).

The plasma 20 is poured on a wafer 3 of a wafer support platform 4 placed in the reaction chamber 2 along a magnetic field formed by a first solenoid 7 and reacts with a reacting gas 13 (e.g., silane: SiH_4) to form, e.g., a silicon nitride film. Sometimes a RF bias is applied to the surface of wafer 3 by a RF power source 14. A window 6 prevents the divergence of said plasma 20 outside the surface of wafer 3. Moreover, an exciting current is not supplied to a second solenoid 8 in the surface treatment of said wafer 3, therefore the second solenoid 8 does not produce a magnetic field.

Next, a plasma cleaning is illustrated. Reaction products deposit on the inner surface of a shield 17 in the plasma processing and then peel off. The plasma cleaning is carried out in some period of said plasma processing to prevent it. In the plasma cleaning, a plasma cleaning gas 11 such as an etching gas, etc. is fed to the plasma generating chamber 1 in place of the plasma generating gas 12 and a microwave 10 is introduced to make the plasma cleaning gas into a plasma, e.g., as shown in the drawing, the plasma is led to the inner surface of said shield 17 along a cusp magnetic field 22 generated in the first and the second solenoids 7, 8 to collide with the surface, and the

reaction products deposited on the inner surface of shield 17 are removed by the etching effect of a plasma cleaning gas. Thus, the removal of said reaction products on the inner surface of shield 17 can be carried out alternately with the plasma processing only by switching operation of valves.

Fig. 1 shows one actual example of present invention. In the drawing, same symbols are attached to same members as Fig. 4, thus their description is omitted. A cooling tube 18 is wound on the cylindrical shield 17 and a coolant 19 (e.g., water, /3 freon, etc.) is circulated. The shield 17 is commonly made of aluminum to prevent contamination of said wafer by heavy metals and has a large cooling effect because of good thermal conductivity. The inlet and outlet of said coolant on the wall of said vacuum vessel take an air-tight structure and said cooling tube 18 on the shield side and the coolant inlet tube 25 on the vacuum vessel side are joined via a non-illustrated connector, which enables to remove the shield 17 independently in a state integrated with the cooling tube 18 during maintenance and management of the system. Moreover, in the drawing, symbol 21 shows flows of cleaning plasma led to the inner surface of said shield 17 by the cusp magnetic field generated by the first and the second solenoids 7, 8.

Fig. 2 shows another actual example of present invention. In the drawing, same symbols are attached to same members as Fig. 1

and Fig. 5, thus their description is omitted. The shield 27 takes a double cylindrical structure, and the coolant 19 is circulated to cool the shield 27.

Fig. 3 and Fig. 4 show the structures of said shields 17 and 27 used in the equipments of Fig. 1 and Fig. 2, and windows for plasma measurement are formed in the shields. The number of windows is taken to be plural, e.g., probes are inserted from the atmosphere side to the inner side of shields via the reaction chamber 2, thus information of plasma and sample can be obtained in the plasma treatment.

Furthermore, cases of applying the present invention to microwave plasma CVD equipments in which a plasma generating gas 12 is made into a plasma at a high density by a resonance effect of a microwave and a magnetic field generated in the plasma-generating chamber 1 by the first solenoid 7 in the both actual examples shown in Fig. 1 and Fig. 2 as plasma processing equipments, but all plasma processing equipments using a high-frequency power source, a direct-current source or their combination are included in the present invention. The plasma cleaning can be carried out efficiently at a proper high temperature for not evaporating base material of the shields 17, 27 by feeding the coolant 19 in all the equipments while a plasma cleaning gas is made into a plasma until a possible maximum plasma density of equipments by supplying the coolant 19 via a

valve with a flow rate controllable valve.

[Effects of the Invention]

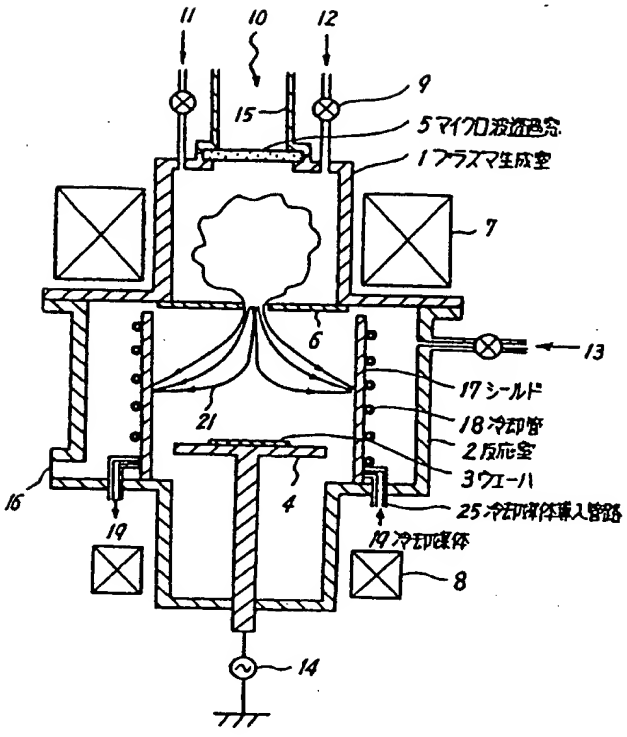
As described above, a plasma processing equipment in which a plasma is generated in a vacuum vessel and the surface of a sample arranged in said vacuum vessel is treated by this plasma takes a constitution provided with a shield for shielding the inner wall of said vacuum vessel arranged between the sample and the inner wall of said vacuum vessel and a coolant introduction pipe for introducing a coolant for cooling said shield into the vacuum vessel, therefore this invention enables to prevent a temperature rise of said shield even if the shield is cleaned by a plasma with a higher density than that in the conventional plasma processing equipment, efficiently remove reaction products deposited on the inner surface of said shield at a proper high temperature by regulating the flow rate of said coolant introduced into the vacuum vessel and sharply shorten the cleaning time than before.

IV. Simple Description of the Drawings

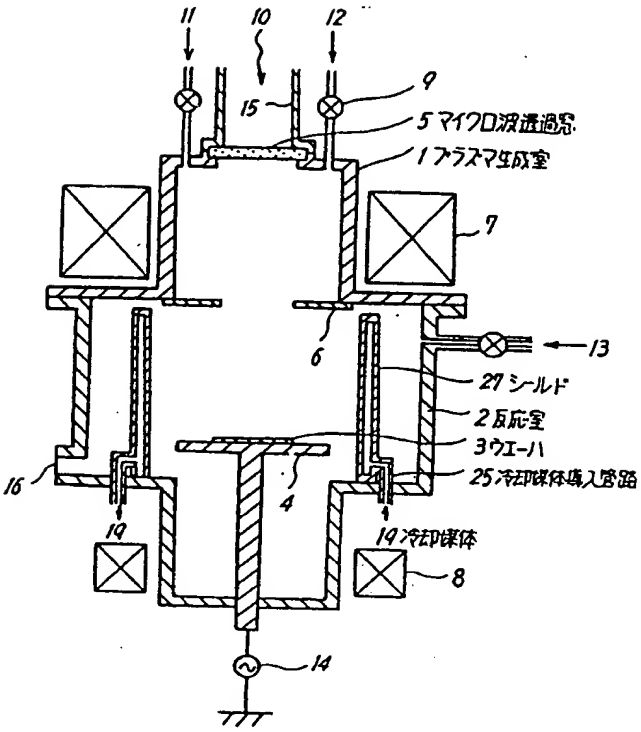
Fig. 1 is longitudinal cross-sectional view showing constitution of plasma processing equipment based on one actual example of present invention, Fig. 2 is longitudinal cross-sectional view showing constitution of plasma processing equipment based on another actual example of present invention, Fig. 3 and Fig. 4 are front views showing appearance of shields

in Fig. 1 and Fig. 2, respectively, and Fig. 5 is longitudinal cross-sectional view showing constitution example of conventional plasma processing equipment.

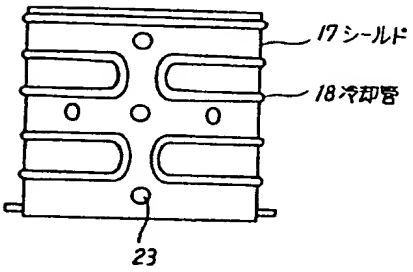
1	:	plasma generating chamber
2	:	reaction chamber
3	:	wafer (sample)
5	:	microwave transmitting window
17,27	:	shields
18	:	cooling tube
19	:	coolant
20	:	plasma
25	:	coolant introducing pipe



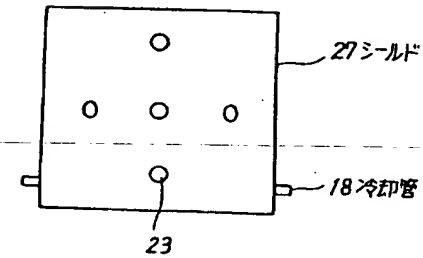
第 1 図



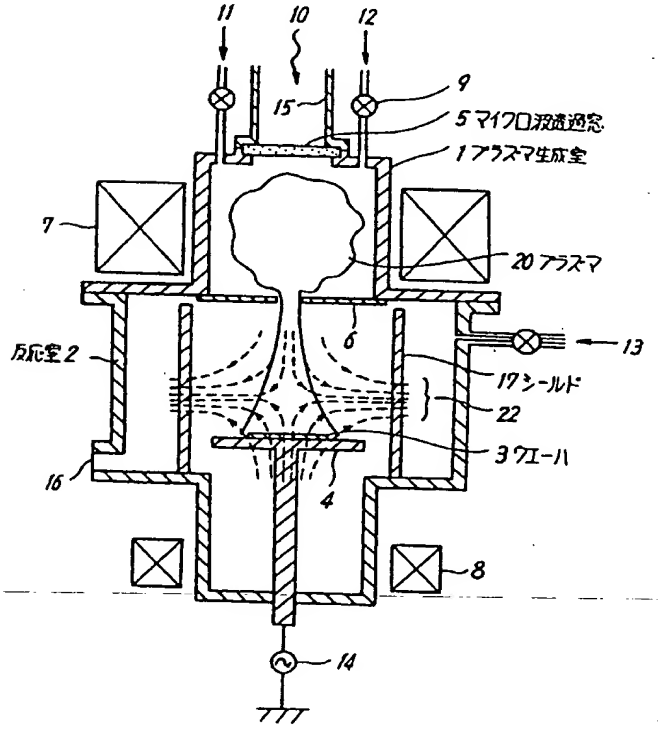
第 2 図



第 3 図



第 4 図



第 5 図

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⑭発明の名称　プラズマ処理装置

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明　細　書

1. 発明の名称　プラズマ処理装置

2. 特許請求の範囲

1) 真空容器内でプラズマを生成し、このプラズマを利用して該真空容器内に配された試料の表面を処理するプラズマ処理装置において、試料と真空容器内壁との間に配され該真空容器内壁をプラズマから遮蔽するシールドと、該シールドを冷却するための冷却媒体を真空容器内に導入するための冷却媒体導入管路とを備えたことを特徴とするプラズマ処理装置。

3. 発明の詳細な説明

(産業上の利用分野)

この発明は、真空容器内でプラズマを生成し、このプラズマを利用して該真空容器内に配された試料の表面を処理するプラズマ処理装置に係り、プラズマ処理時に真空容器内壁面に堆積付着する反応生成物除去のためのプラズマ洗浄を迅速に行うプラズマ処理装置の構成に関する。

(従来の技術)

プラズマCVD装置のように、プラズマを利用してウェーハなどの試料表面を処理するプラズマ処理装置においては、真空容器を構成するステンレス鋼から発生するCr, Ni等による重金属汚染を防止するため、特開昭61−133386号公報に代表されるように、真空容器内壁面をプラズマから遮蔽するシールドを設ける必要がある。しかし、このシールドの内表面にはプラズマ処理中に反応生成物が堆積し、やがて剥離する。これが試料表面に付着して不良品の原因となったり、真空を保持するOリングに付着して真空洩れを起こし、装置の稼動率を低下させる。

これらを改善する従来技術に特開昭60−59739号公報に代表されるプラズマ洗浄法がある。これは、エッチングガスなどからなるプラズマ洗浄ガスをプラズマ化し、これを洗浄対象壁面に作用させて壁面の付着物を除去するものであるが、洗浄時間が長いという欠点があった。その対策として、本願と同一出願人から、真空容器内にカスプ磁界を発生させ、この磁界をプラズマに作用さ

せて洗浄対象壁面の円周上にプラズマを集め、カスプ磁界をシールドの上下方向に移動させて効率的に洗浄する方法が先に提案されている（出願中、出願番号未詳）。

（発明が解決しようとする課題）

カスプ磁界を用いてプラズマ洗浄を行うとき、プラズマがシールド内壁の一部分に集中し、加熱される。特開昭６３－２５４７３１号公報によれば、シールドの加熱はプラズマ洗浄時間を短縮するが、一方、加熱され過ぎて、シールド母材そのものが蒸発する恐れがある。従ってプラズマ密度は制限され、洗浄時間短縮には限界がある。

また、カスプ磁界は用いず、プラズマに投入するエネルギーを増して洗浄時間を短縮しようとしても、同じようにシールドが異常加熱され、洗浄時間短縮には限界があった。

この発明の目的は、プラズマ密度を制限することなく対象壁面の洗浄が可能であり、これにより洗浄時間が従来よりも大幅に短縮されるプラズマ処理装置の構成を提供することである。

（課題を解決するための手段）

上記課題を解決するために、この発明においては、真空容器内でプラズマを生成し、このプラズマを利用して該真空容器内に配された試料の表面を処理するプラズマ処理装置を、試料と真空容器内壁との間に配され該真空容器内壁をプラズマから遮蔽するシールドと、該シールドを冷却するための冷却媒体を真空容器内に導入するための冷却媒体導入管路とを備えた構成とするものとする。

（作用）

このように、試料と真空容器内壁とをシールドで隔離し、このシールドを真空容器外部から導入された冷却媒体を用いて冷却する装置構成とすることにより、シールドの内表面の異常加熱が防止され、また異常加熱の原因となるプラズマ密度に応じて冷却媒体流量の調整も可能となるから、カスプ磁界を用いたプラズマ洗浄の際にも、可能最大のプラズマ密度までシールド母材を蒸発させることなく洗浄が可能となり、洗浄時間が従来より大幅に短縮される。

（実施例）

まず、本発明が対象とするプラズマ処理装置の一例として、第５図のマイクロ波プラズマＣＶＤ装置を説明する。プラズマ生成室１，反応室２，マイクロ波透過窓５で囲まれた空間が、排気口16を通して図示されない排気装置で真空に排気される。大気側から導波管15を通して導入されたマイクロ波10は、マイクロ波透過窓５を透過し、プラズマ生成ガス12（例えば窒素：N_2）をイオン化してプラズマ20を生成する。

プラズマ20は第１ソレノイド７が生成する磁界に沿って、反応室２の中に設置されたウェーハ支持台４上のウェーハ３に降り注ぎ，反応ガス13（例えばシラン：SiH_4）と反応してウェーハ３の表面に例えば窒化シリコン膜を形成する。ウェーハ３にはRF電源14によりRFバイアスが印加される場合もある。窓６はプラズマ20がウェーハ表面以外に発散するのを防ぐ。なお、ウェーハ３の表面処理中は第２ソレノイド８には励磁電流が供給されず、従って第２ソレノイド８は磁界を生成しない。

次にプラズマ洗浄について説明する。シールド17の内面には，プラズマ処理中に反応生成物が堆積し、ついには剥離ずる。それを防止するためにプラズマ処理のある周期でプラズマ洗浄を行う。プラズマ洗浄は、プラズマ生成ガス12の代りにエッチングガスなどのプラズマ洗浄ガス11をプラズマ生成室１に供給するとともにマイクロ波10を導入してプラズマ洗浄ガスをプラズマ化し、これを例えば図のように第１，第２ソレノイド７，８で生成したカスプ磁界22に沿いシールド17の内表面に導いて衝突させ、シールド17の内表面に堆積した反応生成物をプラズマ洗浄ガスのエッチング作用により除去するものである。このように、プラズマ洗浄によれば、シールド内表面の反応生成物の除去をバルブの切り替え操作だけでプラズマ処理と交互に行うことができる。

第１図に本発明の一実施例を示す。図中、第４図と同一の部材には同一符号を付し、説明を省略する。円筒状のシールド17には冷却管18が巻き付

けてあり、冷媒19（例えば水，フロンなど）が循環する。シールド17はウェーハの重金属による汚染を防ぐため通常アルミニウム製であり、熱伝導が良いので冷却効果は大きい。なお冷媒の真空容器壁の出入り口は気密構造をとっており、シールド側冷却管18と真空容器側冷却媒体導入管路25との接合は図示されないコネクターを介して行っており、装置の保守管理時にはシールド17を冷却管18と一体化された状態で単独に取り外し可能である。なお、図において、符号21は、第1，第2ソレノイド7，8により生成されたカスプ磁界によりシールド17の内表面に導かれる洗浄用プラズマの流れを示す。

第2図に本発明の別の実施例を示す。図中，第1図および第5図と同一の部材には同一符号を付し、説明を省略する。シールド27は二重円筒構造としており、冷媒19は二重円筒の内部を循環してシールド27を冷却する。

第3図および第4図はそれぞれ第1図および第2図の装置に用いられているシールド17および27の構造を示すものであり、シールドにプラズマ計測用の窓が形成されている。窓の数は複数とし、大気側から反応室2を通して例えばプローブをシールドの内側へ挿入し、プラズマ処理中にプラズマや試料の情報を得ることができる。

なお、第1図および第2図に示す実施例では、いずれもプラズマ処理装置として、マイクロ波と，第1ソレノイド7がプラズマ生成室1内に生成する磁界との共鳴効果によりプラズマ生成ガス12を高密度にプラズマ化するマイクロ波プラズマＣＶＤ装置に本発明を適用した場合を示しているが、プラズマの生成に高周波電源，直流電源またはこれらの組合わせを用いたプラズマ処理装置の全てが本発明に包含される。いずれの装置においても冷却媒体19を流量調整可能な弁を介して供給することにより、装置の可能最大のプラズマ密度までプラズマ洗浄ガスをプラズマ化しつつ、シールド17，27の母材を蒸発させない適宜の高温でプラズマ洗浄を効率的に行うことができる。

〔発明の効果〕

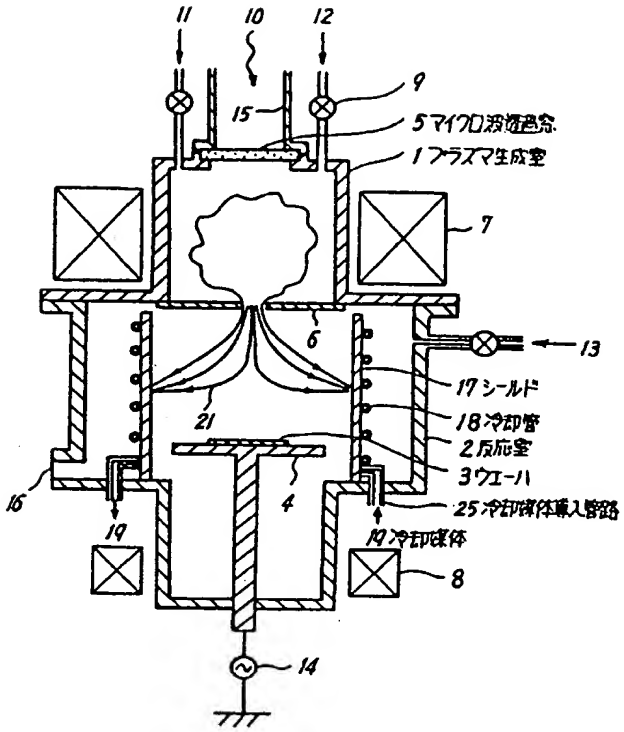
以上に述べたように、本発明では、真空容器内でプラズマを生成し、このプラズマを利用して該真空容器内に配された試料の表面を処理するプラズマ処理装置を、試料と真空容器内壁との間に配され該真空容器内壁をプラズマから遮蔽するシールドと、該シールドを冷却するための冷却媒体を真空容器内に導入するための冷却媒体導入管路とを備えた構成としたので、従来のプラズマ処理装置より高密度のプラズマでシールドを洗浄してもシールドの温度上昇が防止され、真空容器内に導入される冷却媒体の流量を調整して適宜の高温でシールドの内表面に堆積した反応生成物を効率よく除去することができ、洗浄時間を従来と比べて大幅に短縮することができる。

4.図面の簡単な説明

第1図は本発明の一実施例によるプラズマ処理装置の構成を示す縦断面図、第2図は本発明の別の実施例によるプラズマ処理装置の構成を示す縦断面図、第3図および第4図はそれぞれ第1図および第2図におけるシールドの外観を示す正面図、第5図は従来のプラズマ処理装置の構成例を示す縦断面図である。

1：プラズマ生成室、2：反応室、3：ウェーハ（試料）、5：マイクロ波透過窓、17，27：シールド、18：冷却管、19：冷却媒体、20：プラズマ、25：冷却媒体導入管路。

代理人弁理士 山口 昭



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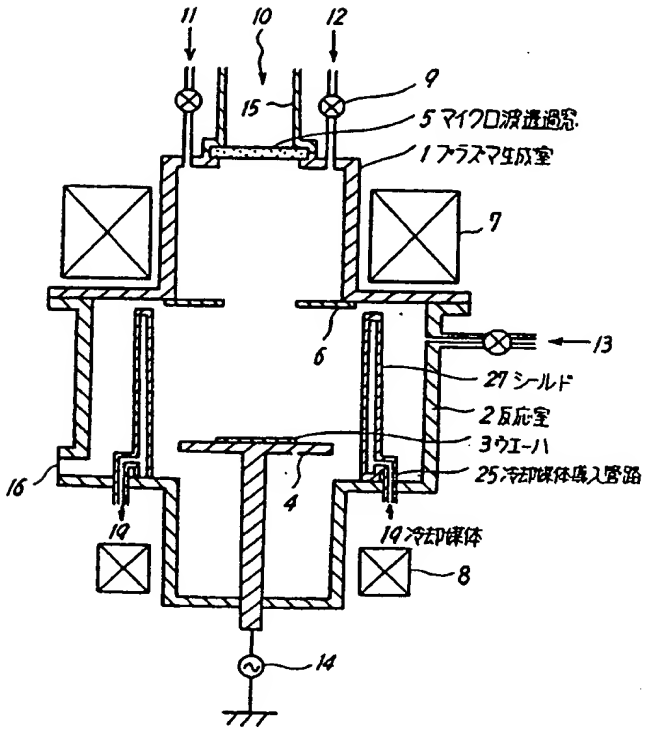

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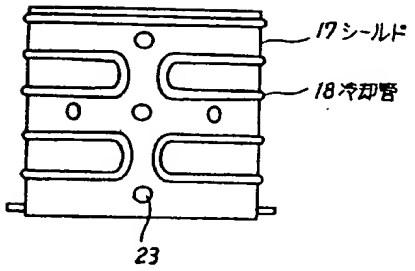

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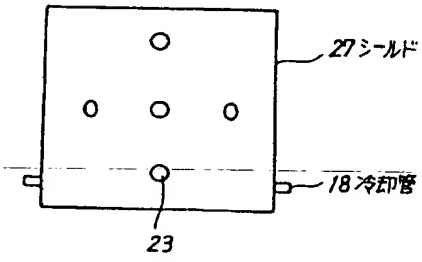

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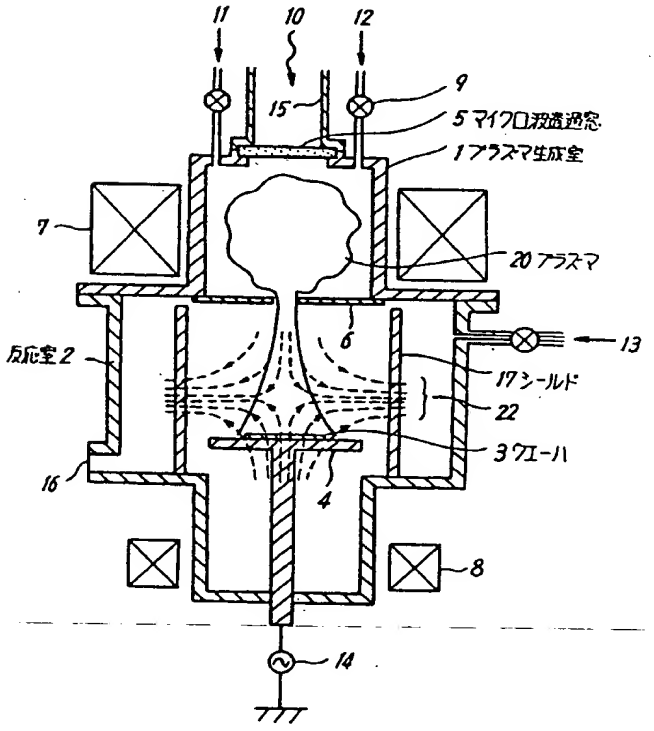

第 5 図

PATENT ABSTRACTS OF JAPAN

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H01L 21/31

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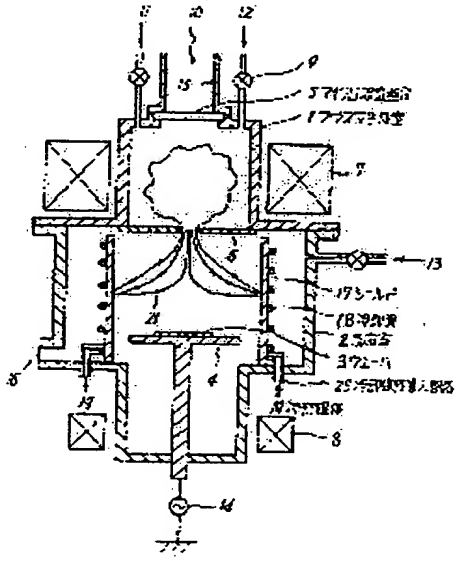
(22)Date of filing : 19.09.1989

(71)Applicant : FUJI ELECTRIC CO LTD
(72)Inventor : ISHIOKA HISAMICHI

(54) PLASMA TREATING DEVICE

(57)Abstract:
PURPOSE: To provide a plasma cleaning apparatus capable of substantial reduction of time required for cleaning by a structure that comprises a shield for protecting the inner wall of a vacuum chamber and cooling pipe for the shield.
CONSTITUTION: Cleaning gas 11 such as an etching gas is supplied to a plasma chamber 1, and microwave 10 is applied to produce a plasma of the cleaning gas. The plasma is guided along the field furnished by first and second solenoids 7 and 8 onto the inner wall of a shield 17. As a result, reaction products on the wall of the shield are etched away. A cooling pipe 18, in which coolant 19 is circulated, is wound around the cylindrical shield 17. When the shield is cleaned by a high-density plasma, therefore, the shield is kept from heating. The flow rate of the coolant to a vacuum chamber is so adjusted that the reaction products on the inner wall of the shield is effectively removed at controlled temperature. This results in a substantial reduction in time required for cleaning.



LEGAL STATUS

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